

Development of a Ground-Based Analog to the Advanced Resistive Exercise Device Aboard the International Space Station

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INTRODUCTION

NASA and Wyle engineers constructed a Horizontal Exercise Fixture (HEF) that was patented in 2006. Recently modifications were made to HEF with the goal of creating a device that mimics squat exercise on the Advanced Resistive Exercise Device (ARED) and can be used by bed rest subjects who must remain supine during exercise. This project posed several engineering challenges, such as how best to reproduce the hip motions (we used a sled that allowed hip motion in the sagittal plane), how to counterweight the pelvis against gravity (we used a pulley and free-weight mechanism), and how to apply large loads (body weight plus squat load) to the shoulders while simultaneously supporting the back against gravity (we tested a standard and a safety bar that allowed movement in the subject's z-axis, both of which used a retractable plate for back support).

METHODS

An evaluation of the HEF was conducted with human subjects (3F, 3M), who performed sets of squat exercises of increasing load from 10-repetition maximum (RM) up to 1-RM. Three pelvic counterweight loads were tested along with each of the two back-support squat bars. Data collection included 3-dimensional ground reaction forces (GRF), muscle activation (EMG), body motion (video-based motion capture), and subjective comments. These data were compared with previous ground-based ARED study data.

RESULTS

All subjects in the evaluation were able to perform low- to high-loading squats on the HEF. Four of the 6 subjects preferred a pelvic counterweight equivalent to 60 percent of their body weight. Four subjects preferred the standard squat bar, whereas 2 female subjects preferred the safety bar. EMG data showed muscle activation in the legs and low back typical of squat motion. GRF trajectories and eccentric-concentric loading ratios were similar to ARED.

CONCLUSION: Squat exercise performed on HEF approximated squat exercise on ARED.